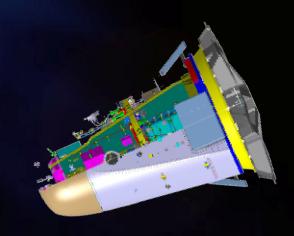


Instrumentation on board the European Experimental Re-entry test bed EXPERT

F. Ratti, J. Gavira, A. C. Thirkettle, J. Thoemel, H. Ritter ESA-ESTEC





EXPERT Consortium

ESA funded project:

Thales Alenia Space Italia as Prime Contractor

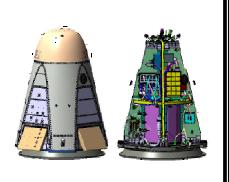
➤ Sub-contractors from 6 European countries (I, D, A, B, NL, CH)

Set of 14 scientific payloads from European Institutes under ESA contract

> experiments from CIRA, DLR, IRS, ALTA, INASMET, HTG, RUAG, VKI

Russian supplier of launcher, DLS and recovery operations

ESA provides technical management and technical support



































Thales Alenia Space ETCA









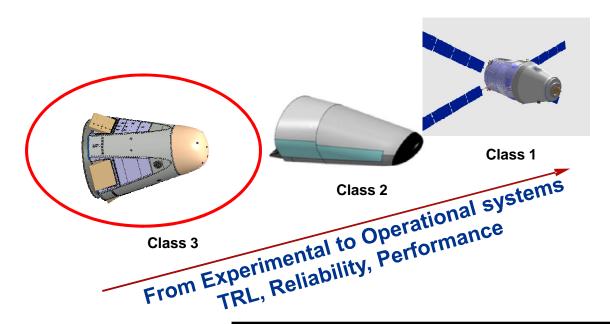


von Karman Institute for Fluid Dynamics





EXPERT the ESA test bed



CLASS 1	
	Full scale demonstration and qualification.
	Performance envelopes are gradually extended
Example:	Shuttle, Buran, Apollo, ARD, X38, Hermes
In development:	ARV
	Class 2
Experime	ntal vehicles for in-flight qualification of system and subsystems
Example:	IRDT for inflatable systems, BOR4 and HYFLEX for TPS, BOR5 and ALFEX
	for GNC, etc
In development:	IXV
	Olege 2
	Class 3
	earch for design tool/physical model validation and improvements
Example:	Mirka, Express, SHARP B1, B2 Flights, HYSHOTS
In development:	EXPERT

Built on experience gained in past projects -> ARD, X38, Huyghens





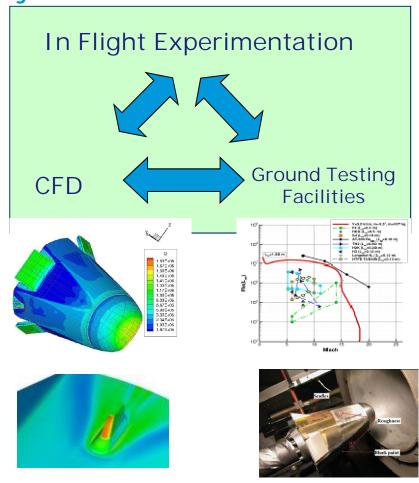


Technological development beneficial for re-entry probes



EXPERT Objectives

- Acquisition of in-flight measurements for critical AD/ATD phenomena (e.g. L/T, catalysis, gas surface interactions)
- Validation of CFD tools
- Validation of wind tunnel test facilities
- Consolidation of ground-to-flight extrapolation methodologies
- To provide European industry with experience of re-entry vehicle manufacturing
- To demonstrate re-entry technologies non ablative nose metallic hot structure
- To advance technologies for supersonic descent and landing
- Provide a test bed for re-entry experimentation







EXPERT Mission

RE-ENTRY capsule performing a sub-orbital ballistic flight at 5 km/s

- Blunt nose, Conical profiles
- Lateral flat sides & Four fixed open flaps
- 1.6 m length & 1.1 m diameter with mass below 450 Kg

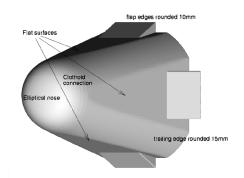
Submarine Launched by VOLNA (ICBM)

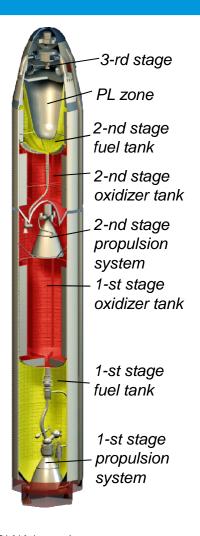
Drogue supersonic parachute and main parachute

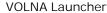
Soil landed and recovered in Kamchatka Peninsula









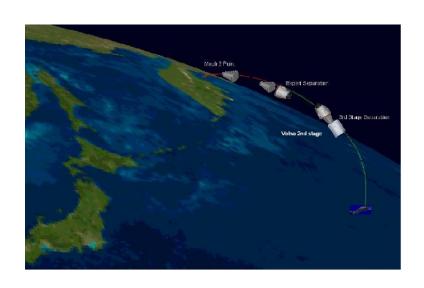


European Space Agency





Mission animation







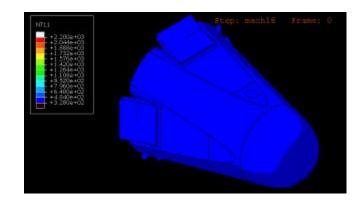


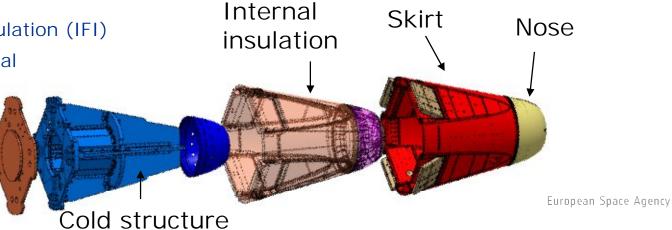
Thermal protection system of EXPERT

1. TPS elements

- a. shell elements
 - Nose (highest temperatures ~2300K)
 - Skirt (moderate temperatures ~1500K)
 - Flaps (highest temperatures ~2300K)
- b. insulation elements
 - Nose Ceramic
 - Skirt Metallic TPS
 - Internal Flexible Insulation (IFI)
 - Rear Thermal External











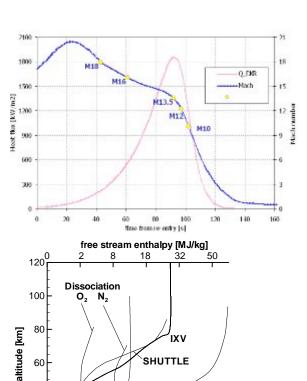
Q

1.83E+06 1.67E+06

1.50E+06 1.48E+06 1.41E+06 1.33E+06

1.17E+06 1.00E+06 8.33E+05 6.67E+05 5.00E+05 3.33E+05 2.34E+05 1.93E+05 1.67E+05

Re-entry environment

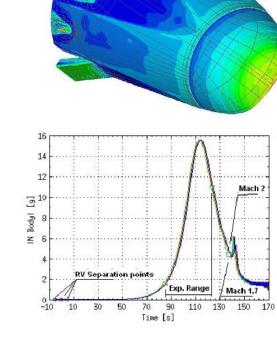


APOLLO

4 6 velocity [km/s]

EXPERT

40

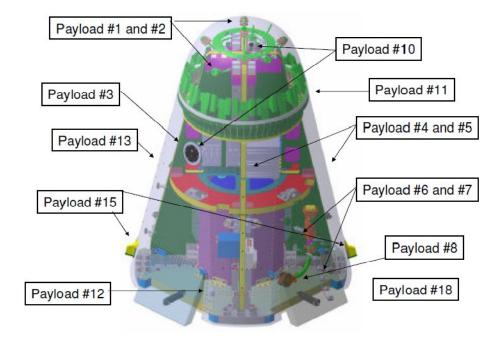






Sensors and experiments on board EXPERT

- o P/L #01 FADS Flush Air Data System
- o P/L #02 PYREX Nose Heating
- o P/L #03 PHLUX Catalysis
- o P/L #04 Natural transition
- o P/L #05 Roughness induced transition
- o P/L #06 SWBLI onto Flaps
- o P/L #07 SWBLI ahead of Flaps
- o P/L #08 Flap Heating
- P/L #10 RESPECT Shock-layer chemistry through spectrometry
- o P/L #11 Nose-TPS Step Junction
- o P/L #12 Base Flow
- o P/L #13 SFS Skin Friction Sensors
- o P/L #15 Flying Winglet Sharp Hot Structure "SHS"
- o P/L #18 Inter-metallic TPS Flight Experiment







Nose







C/C-SiC Nose Assembly (DLR)

- o 6 mm thick shell with 27 Carbon fibre layers
- o Interface with Hat profiles cured in hot press
- o Shell and Hat profiles pyrolised and bonded together with polymeric matrix
- o Optimised number of sheets per layer to avoid delaminations during curing
- o Liquid Silicon Infiltration (LSI) process to fill micro-cracks in the Carbon matrix







Sensors on the nose: Flush air data system

Objectives;

Determine pitch and side slip angle Stagnation point heating Reconstruct free stream density

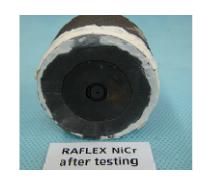
Sensors:

Combined pitot probe/calorimeter

Principle Investigator:

TG Goettingen, Germany

Tested in Plasma at DLR L3K and IRS











FADS sensor head assembly





European Space Agency



Tubing and Wiring / Calorimeter installation

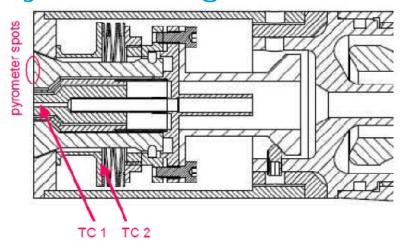




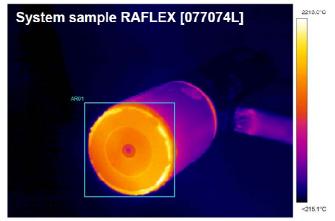


Flush mounted air data system on ground test

- Dedicated holder built for test in plasma
- temperatures were monitored inside and on the exposed surface of the holder
- Temperature reached on the surface of the sample up to 2000 C
- Tested at stagnation pressure of 1.3 bar





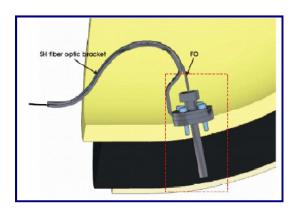






Pyrometers for nose monitoring

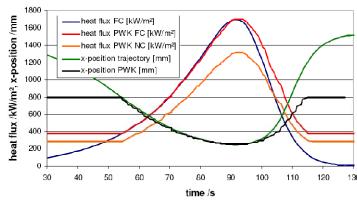
- ObjectivesDetermine Nose Heating
- Sensors:
 - 6 Miniaturized Pyrometers
- Principle Investigator:IRS, Stuttgart, Germany

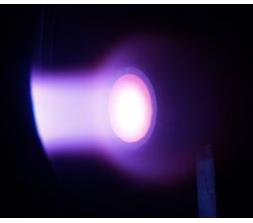
















Spectrometer windows – PL10

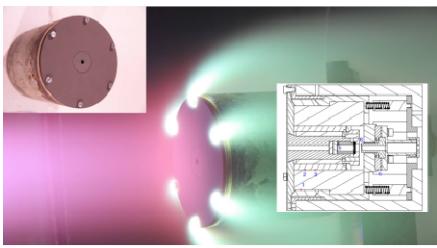
Objectives:

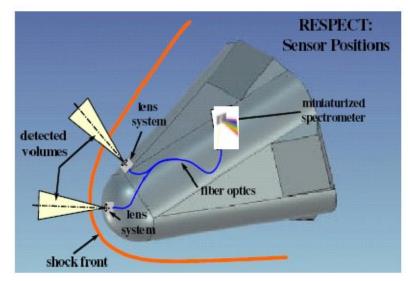
Determine gas phase state in shock layer

Sensors:

Two spectrometers VIS NIR

Principle Investigator:IRS, Stuttgart, Germany











Spectrometer window Sensor Head Assembly







Natural transition – PL4

Objectives:

Determine onset of Naturar transition

Sensors:

Thermocouples

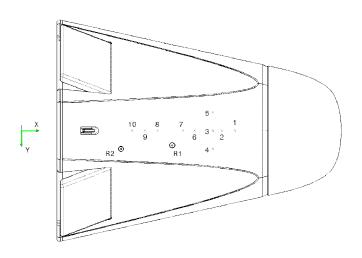
Heat flux sensors

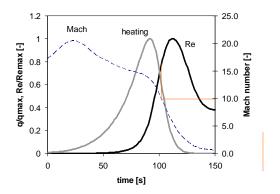
Pressure sensors

Principle Investigator:

CIRA, Capua, Italy

Expected transition at Mach 10 after peak heating









Roughness induced transition – PL5

Objectives:

Determine Onset of Roughness Induced Transition

Sensors:

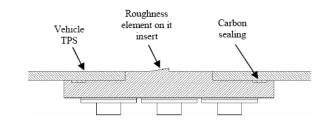
thermocouples

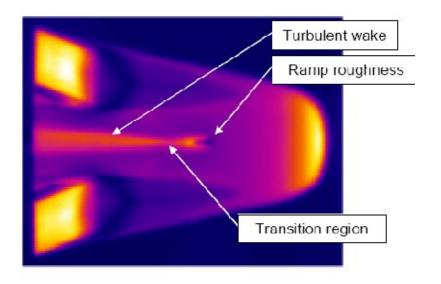
Principle Investigator:

Von Karman Institute, Belgium

 Different roughness element tried before choosing the ramp configuration











Shock wave boundary layer ahead of the flap - PL7

Objectives:

Determine flap performance Heating/SWBL/transition

Sensors:

Thermocouples

Pressure port

Heat flux sensors

Principle Investigators:

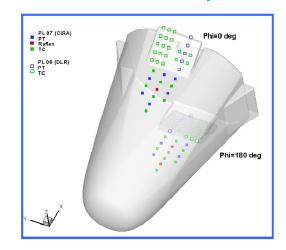
CIRA, Capua

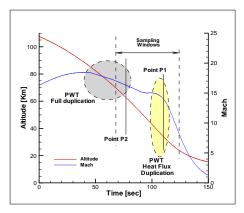
DLR Cologne

 Tested in Scirocco in condition representative of a point of the trajectory at high altitude













Instrumented flap – PL6

- Pressure ports located on 2 of the 4 flight flaps
- Thermocouples located behind the flap













Thermocamera behind flap - PL8

Objectives:

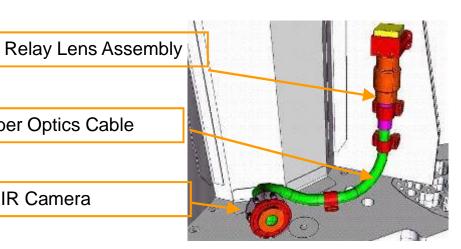
Determine heating

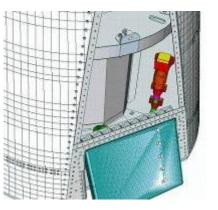
Sensors:

IR thermography

Principle Investigator:

RUAG Aerospace, Wallisellen, Switzerland

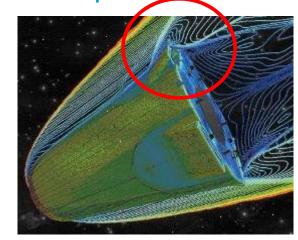








NIR Camera

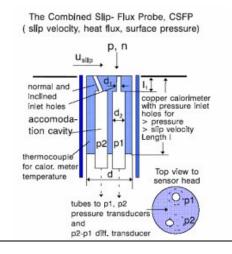


Fiber Optics Cable



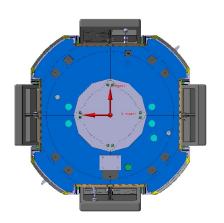
Skin Friction – PL13 and pressure sensors – PL12

- Objectives:
 - Determine skin friction
- Sensors:
 - 2+2 pressure sensors and calorimeters
- Principle Investigator: HTG, Goettingen, Germany



- Objectives:
 - Determine base flow characteristics (heating, drag and stability)
- Sensors:
 - 4+2 pressure sensors and calorimeters
- Principle Investigator:
 - ALTA, Pisa, Italy

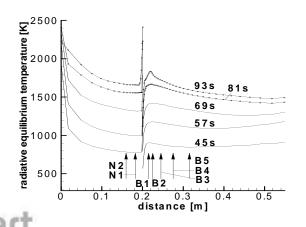


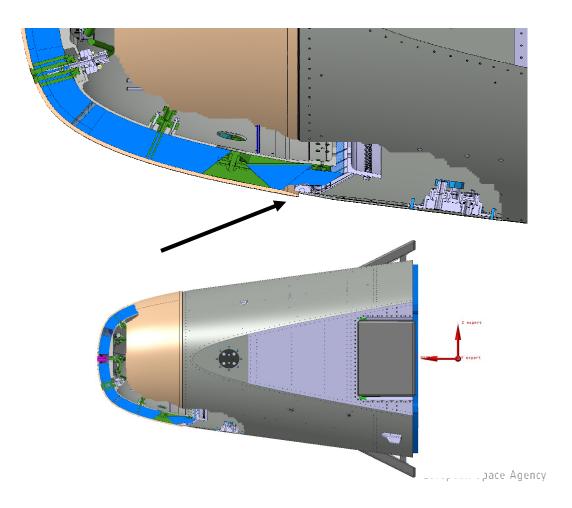




Instrumented TPS Junction - PL11

- Objectives:
 - Detect and quantify catalytic effect
- Sensors:
 - 7 Thermocouples
- Principle Investigator:
 - Von Karman Institute









Winglet in UHTC

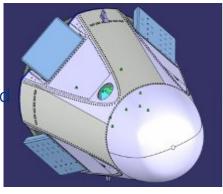
Objectives:

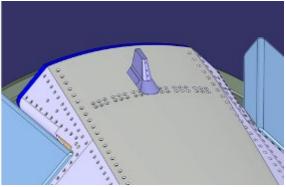
Test a sharp hot structure in flight conditions

Sensors:

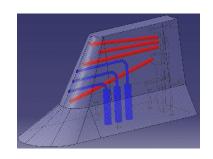
Winglets are equipped with thermocouples and pressure taps

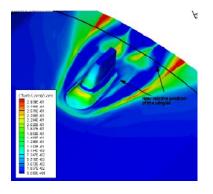
Principle Investigator: CIRA, Capua, Italy

















Sample of intermetallic material – PL18

Objectives:

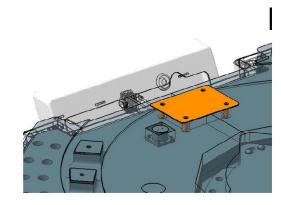
Test orthorhombic titanium aluminide (Ti2AlNb) in flight conditions

Sensors:

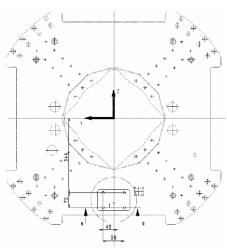
tile is equipped with thermocouples

Principle Investigator:

INASMET, San Sebastian, Spain









European Space Agency



Conclusion

- ESA has selected and managed the development of a set of consistent experiments for re-entry experimentation
- Extensive CFD campaign and ground qualification campaign in European ATD facilities (DLR, CIRA, IRS, VKI, ALTA)
- Several Lessons learned
 - Demanding mechanical environment for vibration and shock
 - Difficult IF between different TPS material (CMC and metallic TPS)
- Vehicle and Payloads currently under integration, System test end 2010
- Readiness for flight early 2011 and expected launch mid 2011

